A NEW GEOTRICHUM FROM A BRONCHIAL AND PULMONARY INFECTION, GEOTRICHUM VERSIFORME MOORE, N. SP.[1]

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Introduction

The purpose of this paper is to report the occurrence of a case of a bronchial and pulmonary infection from St. Louis, Missouri, and also to present the characteristics of a *Geotrichum* isolated from it. The organism is described as a new species, and from all indications it was the probable etiologic agent of the disease.

The genera *Geotrichum, Mycoderma, Oidium, Oospora, Monilia,* and several others have been confused by numerous authors. Nomenclature has been changed, terms have been discarded and others have sprung up, but apparently no universal agreement has been reached by all interested mycologists. The author wishes to indicate some important facts as to the structure and differentiation of the fungus, as well as to point out apparent misnomers and the correct position of such incorrectly determined organisms.

Case Report

Clinical History.—Barnes Hospital Clinic No. C 17521. Patient F. S., a white male, 22 years of age, a chemist, entered the clinic March 9, 1931, for some ailment to be shown later, and was then released. He re-entered December 31, 1932, with a persistent, productive cough which brought up a thick, greenish, muco-purulent, tenacious sputum.

Family History.—Mother died in childbirth 15 years previously. Father living and well. One brother living and well.

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Past History.—Whooping cough when child. Pneumonia 6 years previously; in bed 2 weeks and no sequelae. Measles in January, 1931, followed by a mastoiditis. Mastoidectomy performed at the Barnes Hospital in February, 1931. Two or three attacks of tonsillitis since 14 years of age, with abscess at one time. Ton sillectomy performed at the Barnes Hospital, June 6, 1931.

Personal History.—Wassermann and Kahn negative.

Present Illness.—About 7 years previously, while a student in high school, the patient kept irregular hours and began to have a more or less persistent cough, on one occasion the sputum being bloody. Cough continued for several years, usually worse in the morning, and about one to two tablespoonsful of sputum, occasionally bloody, was coughed up. The summer before entry, patient was in the open a great deal and the cough subsided. About a month previous to entry, he developed a fever with generalized pains. He was confined to his bed and since that time the cough became more persistent and painful and troubled him mostly at night.

A chest examination revealed a few squeaks. Fluoroscopic examination showed little. In view of the history of chronic cough, sputum examination was advised and X-ray with flat plate on sternum.

January 4, 1933.—To date the presence of an infection or dangerous condition not indicated. Further examination to be carried out.

January 9, 1933.—Patient fairly well, but complained of persistent cough in morning and occasionally a coughing spell in the afternoon, with which a large amount of pale yellow, occasionally streaked sputum was brought up. Physical findings of lungs showed some roughening on both sides and some increase in left and right lower lungs, with râles.

Diagnosis.—Bronchiectasis. Lipoidal suggested.

January 10, 1933.—Lipoidal introduced into left lung. X-ray showed definite bronchiectasic areas or multiple abscesses. During course of introduction, patient coughed up about 60 cc. purulent material containing bright blood streaks.

January 14, 1933.—Patient returned to the chest clinic. He stated that he had been growing mushrooms for the past year in an underground quarry where the humidity was fairly high. Felt fairly well at the time, but still brought up a moderate amount of sputum. Further examination of sputum for molds.

January 28, 1933.—Definite bronchiectasis of base of left lung. Posterial drainage.

X-ray findings of January 3, 1933.—Posterior-anterior view of chest. Cardiac shadow within normal limits. Tremendous increase of shadow of left hilus and generalized thickening of lung markings throughout the field. Particular widening of those markings lateral to the right cardiac border at the base, associated with a large amount of coarse, soft, slightly coalescent mottling. Cloudiness within the circle of the first rib on either side, at the extreme apex. Leaves of diaphragm rounded and the costophrenic angles clear.

X-ray Diagnosis.—Pulmonary infiltration of left base, indeterminate nature.

The sputum was cultured and the organism described in this paper was isolated in relatively great amounts. The patient was given potassium iodide *per os.* He left St. Louis sometime during the spring of the year 1933, and in a letter to the author, dated June 23, 1933, he stated that his general health had improved, with a gain of five pounds in weight. The pain in the chest had disappeared except for

infrequent periods, the cough was somewhat better, and the amount of sputum had decreased. He had stopped treatment about a month previously. A second communication dated October 26, 1933, stated that his condition had not changed, that he had resumed the previous treatment for a short time but upon finding no marked improvement had again stopped it.

Technique

The fungus was studied in hanging-drop preparations or Van Tieghem cells, in a lactose-broth medium, a product of the Digestive Ferments Co., as well as on Sabouraud's broth, 2 per cent bacto-peptone, and meat extract broth.

For morphological detail and for possible cellular granulations, the fungus was mounted in a 1 per cent aqueous crystal violet solution plus glycerine, the desired amount of dye being added to obtain the necessary intensity. Amann's lacto-phenol was also used, as well as various dyes in aqueous solutions, but the first two were sufficient for all purposes of general structure. Distilled water mounts were made which showed up the oil globules present on the cellular surface.

Description

Geotrichum versiforme macroscopically assumes different conditions, varying from crinkled and vermiculate on malt extract agar to asteroid on Sabouraud's agar. The velvety or plush-like appearance prevails on most culture media, conspicuously so on potato-dextrose and glycerine agar, and many of the cultures, particularly those on meat extract, lactose, and Endo's agar, are moist. On Raulin's and Richards' agar, which contain inorganic sources of nitrogen and several salts, the mycelium is completely submerged. The colonies are tenacious and hard to separate from the substrate. The striations evident on Sabouraud's agar are due to coremia formed by the matting of hyphae. On liquid media, a pellicle is formed on the surface with a fine sediment in the bottom of the flask.

When isolated from the sputum, the fungus is in the form of simple cells, ovoid to spherical, 4–6 μ in diameter. When grown on agar, the cells form a complicated mycelium which eventually breaks up into arthrospores typical of this group. On artificial substrates, the arthrospores serve as the seeds of

the future colonies. The various steps in their formation may be traced as follows: The single cell germinates, sending out a thin-walled tube which may emerge from either end, or laterally (pl. 16, figs. 1–6). The germ-tube may be simple (figs. 7–8) or it may bi- or trifurcate. It elongates and forms cross-walls which may be simple or collar-like (figs. 7–8, 15), either equidistant or irregularly spaced, when secondary cross-walls may develop (fig. 17). With the development of equidistant partitions, the hypha is now divided into a number of cells. Langeron and Talice ('32) observed that the germ-tube may remain simple and undivided, as stated previously, and as such will bifurcate or trifurcate. This was occasionally noted here, but these germ-tubes later became arthrospores. It is to be noted that the hyphae are capable of developing lateral branches (figs. 12, 14–17), which may form simply or as off-shoots at or below a cross-wall. In addition, the so-called blastospores may be formed as suggested in fig. 12.

The presence of a true conidium in *Geotrichum* seems to be much disputed. One cannot help feeling, however, that a pyriform structure such as that in pl. 16, figs. 11, 14, and 16, having the functions of a conidium as noted in other organisms, e. g. *Endomyces,* are very highly suggestive of that organ. There is no doubt that the cells are capable of germinating into a tube which has the same vegetative and reproductive functions as the arthrospores. That being the case, the only reason why that particular cell may not be called a conidium is cytological, and such a study will be reported later.

The young filaments are thin-walled at first, and as the cross-walls are laid down, the thick hyaline walls cause the resulting cells to assume a double-contoured appearance. Just previous to disarticulation, or the breaking up of the filament into the arthrospores, the cells may assume a rectangular appearance (pl. 16, fig. 18), or they may be barrel-shaped (fig. 23). On various media and hydrogen-ion concentrations they may assume different forms, as on malt extract agar (fig. 19) and on Richards' agar (figs. 24, 28) where they are in the form of oidia. It must also be noticed that not all hyphae develop these equidistant cells, for irregularity is likewise well-marked (figs.

19, 22). Also, the smaller cells may be formed only on a portion of the filament, as seen in figs. 27, 30, 32, a condition which is apparent in the Oosporaceae of Saccardo, particularly as seen in fig. 27.

When mature, the thick-walled cells become arthrospores. A gelified secretion seems to be laid down simultaneously between the cells as part of the connecting cell-wall, at the point where disarticulation takes place. The arthrospores appear at first to be cylindrical (rectangular in optical section) (pl. 16, figs. 18, 23), and in many cases (figs. 22, 24) are rounded at the ends. When completely separated from each other, the cylindrical arthrospores become spheroidal, ovoid, or ellipsoid (fig. 26). In a few cases, it is possible to note some of the protoplasm connecting the arthrospores, which has not completely attached itself to the cells, or perhaps part of the cell-wall which has not entered into the formation of the cells, as in fig. 18. The cells may then either remain in the condition described above or they may become spherical, ovoid, or even ellipsoid, and within a suitable period of time germinate to give rise to a new colony.

Several other anatomical structures have been given consideration by various workers and should be noted here. First, not all the hyphae or even a whole filament will divide to form arthrospores. Disarticulation may occur either near the end of a filament as in pl. 16, figs. 27 and 30, or at various segments of a filament. In either case, the intervening portion of the hypha is clear and thin-walled and seems to disintegrate after the arthrospores have been set free. Apparently the cellular material is used up in the formation of the thick-walled cells. On a few occasions, arthrospores or perhaps chlamydospores were found enveloped by a thin membrane (fig. 32), the entire wall evidently not having entered into the development of the spores.

Chlamydospores are found frequently. These are distinguished from the rest of the mycelium by their conspicuous size and seemingly granular protoplasm (pl. 16, figs. 13, 19–20, 23, 33), and in some instances (fig. 33), they simulate the akinetes as found in algae. Cells analogous to terminal chla-

mydospores (hypnospores) are also evident (figs. 29, 31, 34). Chains of oidia-like cells on Richards' agar (fig. 28) are of common occurrence on that medium, and evident also on Raulin's solution agar. Occasionally blastospores occur, either thick- or thin-walled (perhaps suggested by fig. 22).

In addition to the various organs discussed above, the mycelium may be altered, changes in the constituents of the substrate giving rise to numerous structures indicative of standard fungus organs as well as nondescript, sclerotic cells and the racquet mycelium characteristic of various other groups of fungi.

CULTURAL DESCRIPTIONS

The culture obtained in this study was growing on a Sabouraud's glucose-agar slant. The colony assumed a velvety "duvet" appearance, with lines radiating to the periphery, apparently a coremioid condition. Transfers were made to various media which ranged in pH from 4.1 to 7.5, also to more strongly alkaline and more strongly acid media. All cultures were grown at approximately 25° C.

The importance of physiological variations in taxonomic differentiation cannot be stressed sufficiently. Species differentiation founded on growth on a single medium is usually unreliable, and the use of standard media is essential for obtaining the morphological changes. The characteristics here discussed were observed from the growth of the organism on several media which represent a series varying in hydrogen ion concentration, protein and carbohydrate content. The media are arranged in the order of their decreasing concentration of hydrogen ions. The cultures were examined 3–8 days after inoculation and again 210 days later.

Raulin's Solution Agar (pH 4.1).—(pl. 16, figs. 1, 18, 26, 29). Colony dull gray in color, turning faintly cream with age, and attaining a diameter of 6.5 cm. 8 days after inoculation. Smooth and velvety, with a peripheral zone of fine radiate growth. Young culture shows many fine hyphae 2–3 μ in diameter, which develop a great number of cylindrical cells approximately 4 μ in diameter and 7–10 μ long, several round cells ap-

proximately 6–15 μ in diameter, large cells 6 x 15 μ. Short chains of round cells approximately 6 μ in diameter. Chains of arthrospores numerous.

Richards' Solution Agar (pH 4.3).—(pl. 16, figs. 2,22,24,28). Colony of submerged, hyaline mycelium, 5½ cm. in diameter at end of 8 days, with fine radiating lines from the inoculum as seen with the aid of light coming through the agar. Long chains of spherical to rectangular cells 6 x 30–40 μ, large cells varying in diameter from 9 to 21 μ, also variously formed sclerotic cells. Arthrospores and chlamydospores in abundance in older cultures.

Czapek's Agar (pH 4.4).—(pl. 16, figs. 10, 14, 31). Macroscopic appearance similar to that on Richards' agar. Colony 5½ cm. in diameter after 8 days' growth. Long filaments 3 μ in diameter, with enlarged terminal cells 6 x 9 μ. Ovoid cells, arthrospores 6 x 8 μ. Rectangular cells with rounded corners 4 x 6 μ. Elongated cells 3 x 13–15 μ.

Malt Extract Agar (pH 5.2).—(pl. 15, fig. 1; pl. 16, figs. 11, 13, 19–20, 23, 35). Growth irregular and thick in center with a pebbly, vermiculate surface, attaining a diameter of approximately 2½ cm. in 8 days. Colony dull creamy-buff in color, appearing pasty at periphery of colony similar to a yeast culture. Mycelium thick and tenacious, adhering to the substrate and resistant to the needle. Large sclerotic cells, ovoid chlamydospores and arthrospores 20 x 30 μ, and many round cells 15 μ in diameter at center of colony. Variously formed cells and arthrospores varying from 4 to 6 x 6 to 15 μ. Young filaments and yeast-like cells at edge of colony.

Sabouraud's Agar (pH 5.6).—(pl. 15, fig. 2; pl. 16, figs. 3–5, 7, 9, 16, 27, 30). Growth good, 6½ cm. in diameter after 8 days, hyaline to white when young, becoming creamy yellow to light buff when older, with a "duvet" or furry appearance, in sectors, extending from the inoculum. Several colonies showed a moist, shiny, convoluting, cerebriform surface. Mycelium thick with a heavy mucoid tenacity.

With Maltose.—(pl. 16, figs. 27, 30). Round cells approximately 5 μ in diameter, and elongated cells 5 x 8–9 μ. Many thick-walled rounded arthrospores. Young filaments thin-

walled and long, approximately 4–5 x 30–40 μ. Chains of arthrospores numerous in older cultures.

With Glucose.—(pl. 16, figs. 3–5, 7, 9, 16). Cells approximately 3 μ in diameter. Variety of filaments, some branching, long and thin, 2–3 μ in diameter, others short and thick-walled, about 5–6 μ in diameter. Sclerotic cells present, as well as numerous thick-walled arthrospores 5 x 8–10 μ, and chlamydospores (terminal, as hypnospores), pyriform to ovoid and ellipsoid. Lateral cells on a filament similar to conidia, pyriform to round, 6–7 x 5–15 μ. No budding recognizable as such.

Sabouraud's Broth (The above minus the agar, pH 5.6).—(pl. 16, fig. 15). Scum formed on surface of broth with a sediment. Liquid faintly cloudy, becoming clear after a few days. Long filaments with cells approximately 4 x 90 μ. Arthrosporous cells few, 4 x 12 μ. Chlamydospores very few.

Potato-Dextrose Agar (pH 5.9).—(pl. 15, fig. 3; pl. 16, fig. 12). Colony 7 cm. in diameter after 8 days. Cultural appearance similar to that on Sabouraud's agar, with the "duvet," but dull gray to light cream in color. Sectors present showing variability in color, creamy-white as present on Sabouraud's agar. Older cultures plush-like or furry, with a whirl. Long filaments 3 μ in diameter, round cells (chlamydospores) 5–6 μ in diameter; arthrospores numerous, 3–4 x 12–15 μ. Many pyriform loose cells 6 μ in diameter.

Corn-Meal Agar (Product of Digestive Ferments Co., pH 6.0).—(pl. 16, figs. 21, 32–33). Colony 3½ cm. in diameter after 8 days, with distinct zones of decreasing growth from the inoculum to the periphery. Color dull creamy white. Young cultures show long thin-walled hyphae with cells approximately 4–8 x 30–35 μ, many cells varying in same proportions. Large cells show a clear cytoplasm, not taking a stain. Older cultures show an abundance of arthrospores 5–6 x 10–12 μ, as well as large cells of this nature, 9 x 15 μ, round cells 5 μ in diameter. Numerous intercalary chlamydospores, as in fig. 33, simulating akinetes in algae.

Lactose Broth (Product of Digestive Ferments Co., pH 6.8).—(pl. 16, fig. 17). A thin scum or veil on the surface of the

liquid with a macroscopically fine sediment and a clouded condition prevailing throughout for several days. Clusters of hyphae, coremium-like, 4–5 μ in diameter, branching and with cross-walls. Older hyphae, 6 μ in diameter, showing septal formation. Numerous chains of arthrospores 4–6 x 6–11 μ. Ovoid cells 6 x 9 μ.

Lactose Agar (The above plus 2 per cent agar).—(pl. 15, fig. 4). Flat growth of fine filaments, dull gray to light cream in color, with a diameter of 4 cm. after 8 days. Young hyphae 3–4 x 25–35 μ. Older cultures with sclerotic cells and pyriform cells simulating the conidia of *Endomyces capsulatus*. Many large round cells 9–15 μ in diameter, numerous arthrospores 4–5 x 8–11 μ, and many filaments with a terminal club-like appearance.

Glycerine Agar (Beef extract agar plus 6 per cent glycerine, pH 7.0).—(pl. 15, fig. 5; pl. 16, fig. 8). Colony 4.2 cm. in diameter after 8 days, creamy-yellow to light buff in color with a powdery appearance. Center somewhat crateriform, becoming raised, thick and tenacious with age. Slight striations extending from the periphery to the center of the colony. Lateral view of the culture presents a hyaline sheen. Old cultures show numerous arthrospores 3–8 x 8–18 μ; round cells 6–9 μ in diameter; intercalary chlamydospores 6–8 μ in diameter. Filaments or hyphae cross-walled and branching, young filaments with fewer cross-walls and smaller diameter than the older ones. Sclerotic appearance of mycelium similar to that on malt extract agar.

Nutrient Agar (Product of Digestive Ferments Co., pH 7.2).—(pl. 15, fig. 6; pl. 16, figs. 6, 25, 34). Colony moist and flat, cream to light buff in color, with a diameter of 5 cm. in 8 days. Filaments multibranched with racquet-like swellings, a condition prevalent on most cultures and particularly well marked on malt extract and glycerine agar. Hyphae 4 μ in diameter. Older cultures show numerous chains of arthrospores 4–6 x 6–9 μ; round cells 6–12 μ in diameter.

Endo's Agar (Product of Digestive Ferments Co., pH 7.5).—(pl. 15, fig. 7). Cultures flat and pink in color, 3 cm. in diam-

eter after 8 days, moist and shiny with concentric rings of growth and a periphery of fine filaments. Microscopically similar to cultures on nutrient agar.

Gelatine.—After 12 days plain gelatine liquefies slowly on surface at point of inoculation and proceeding downward. Beef extract gelatine (15 per cent) liquefies slowly on surface after 14 days.

Carbohydrate Reactions.—No fermentation on any sugar. Acid and no gas with l-xylose, galactose, d-mannose, levulose, and maltose. No acid, but an alkaline reaction with l-arabinose, rhamnose, dextrose, lactose, sucrose, raffinose, and inulin. Alkalinity may be considered as a negative acidity reaction and may perhaps be accounted for by the breakdown of the protein, amino acids to alkaline bases as arginine, lysine and histidine and finally ammonia, which are the breakdown products in the growth process of the organism.

Litmus Milk.—Acidified and curdled after the fourth day.

DISCUSSION

The genus *Geotrichum* has often been confused with several other genera, e. g. *Mycoderma, Oidium, Oospora* and even *Monilia.* Several of these conflicting forms are so close morphologically that one must rely almost wholly on biochemical reactions for the correct determination of the organism. On the other hand, fungi have been included in one of these groups which apparently have no generic similarity, making the literature abundant with misnomers.

In 1809 Link created the genus *Geotrichum* with the following characteristics (Link, Mag. Naturf. Ges. Fr. Berlin **3**: 17–18. 1809; Saccardo, Syll. Fung. **4**: 39. 1886): "Hyphae steriles repentes; fertiles breves, adscendentes septulatae. Conidia concatenata, breve cylindracea, utrinque truncata, hyalina."

Since the above description, numerous species have been added to the genus. The confusion existing in the literature has been briefly summarized by several authors, particularly Langeron and Talice ('32). From the genus *Mycoderma,* however, *Geotrichum* is to be differentiated particularly, since

these two groups have often been interchanged and even reduced to synonymy by Ciferri and Redaelli ('29).

Mycoderma has been considered to be similar in morphology to *Geotrichum*. However, there is greater gelification of the walls of *Mycoderma*, particularly at the cross-walls, the cells tending to become rounded or ellipsoidal as compared with the cylindrical cells of *Geotrichum*, where the ends remain abrupt or become somewhat rounded. This of course may vary in both genera, making morphological differentiation so difficult that biochemical and physiological reactions must be resorted to. In this respect, it is found that the Geotricha may produce a thick pellicle on liquid media; liquefy gelatine and serum, but do not ferment sugars, usually producing acidity and no gas. In the case of the Mycodermata, it is generally found that the colony surface on media is more folded, with no gelatine or serum liquefaction or fermentation of sugars.

As the majority of the members of the genus *Geotrichum*, as well as of *Mycoderma*, have been isolated from the soil, there are many saprophytes which are not as yet found to be pathogenic on man. In many cases, there have been determinations of fungi based on systems of classification which have either reduced several genera to synonymy or have adopted terms which in many cases do not apply to this group. A few of these may be briefly considered.

Sartory in 1907 placed these fungi in the genus *Oospora*, on the same footing as the Actinomycetes, and confirmed this in 1923 (Sartory et Bailly, '23). Castellani ('19) considered the fungus as *Oidium* Link, 1809, *emendavit* Pinoy, and defined it as "Oosporaceae with hyphae terminating in chains of spores. Hyphae long and branched. Sporophores simple, septate, often without disjunction apparatus. Do not produce gas in carbohydrates." He included four species as pathogens: *Oidium lactis* Link, 1809; *O. rotundatum* Castellani, 1911; *O. asteroides* Castellani, 1914; *O. matalense* Castellani, 1915. Since that time, numerous changes have occurred, and that author has published several new species and varieties of *Geotrichum*, whereas the four above fungi have been placed in *Geotrichum* by other writers. Some of these new organisms

may belong to the last-named group, while certain others are definitely not correct taxonomically.

Berkhout ('23) took up the name *Oospora* for these pathogenic fungi and included in it the genus *Oidium*. Ciferri and Redaelli refer the species to the Torulopsidaceae of the Mucedineae amerosporeae, on the same standing as the Oosporaceae and perhaps in synonymy with the latter. The Torulopsidaceae they further divide into the Torulopsideae, which replaces the former sub-family Cryptococcaceae, and the Mycotoruleae, including thus *Geotrichum*, which they use in preference to *Oospora* and *Mycoderma*. Vuillemin ('31), on the other hand, prefers to keep the group in *Mycoderma*, while Langeron and Talice ('32) classify it with the Mycotorulaceae of Ciferri and Redaelli, placing the genus in their *Geotrichoides*, a sub-group of the family which forms membranaceous colonies and comprises the single genus *Geotrichum*. They characterize the genus as having a true mycelium that breaks up into arthrospores with occasional blastospores, and forming a thick veil on liquid media.

A review of the literature revealed further that very few well-defined species of *Geotrichum* have been reported pathogenic for man. The several species known in literature: *G. pulmoneum* (Bennett) Basgal ('31), *G. asteroides* (Castellani) Basgal ('31), *G. louisianoideum* and *G. multifermentans* Castellani ('33), and several other fungi appearing in such genera as *Mycotorula, Torula, Oidium, Mycoderma, Oospora* and *Monilia*, which from their morphological and biochemical properties should be in *Geotrichum*, have definite characteristics which distinguish them, and possibly not all are correctly named. In addition, two organisms have been published recently with a generic change, namely *G. immite* (Rixford and Gilchrist) Agostini ('32) and *G. dermatitidis* (Gilchrist and Stokes) Castellani ('33). These fungi are of particular interest, since neither one presents characteristics identical with *Geotrichum*. *Geotrichum immite*, the cause of coccidioidal granuloma, furthermore, has been shown to have an ascus in its life cycle which immediately eliminates it from the above group and places it in the Ascomycetes where the author

('32) created the family Coccidioideaceae, with *Coccidioides immitis* as the type genus and species. The second fungus, *G. dermatitidis,* the cause of the American type of blastomycosis, has absolutely no association with the genus. This was also found to have an ascus with 8 spores in its life cycle and was consequently transferred by the author ('33, '33a) to the genus *Endomyces.*

After carefully studying the description of the above species, particularly of *Geotrichum* and the possibly related species in *Mycoderma, Oidium* and *Oospora,* the author concludes that the organism described in this paper should be a new species, *Geotrichum versiforme.*

Geotrichum versiforme Moore, n. sp.

Differs from other species of the genus *Geotrichum* by having many forms on various media. Macroscopically it varies from a velvety plush-like, to a moist, flat, asteroid or vermiculate condition. Color varies from a dull grayish-white to a dull creamy-buff with a "duvet" appearance, as on Sabouraud's and glycerine agar. Microscopically the cells vary in size, proportion, and development; hyphae 3–8 μ in diameter, with young cells approximately 6–40 μ long; arthrospores 4–9 x 6–18 μ; spherical chlamydospores 4–18 μ in diameter, elongated ones 6–8 x 20–30 μ; small spherical cells 4–6 μ in diameter, possibly blastospores; conidium-like cells, spherical 4–6 μ in diameter, pyriform 3–4 x 4–6 μ. No fermentation on any sugar. Acid and no gas after 2 days on l-xylose, galactose, d-mannose, levulose, and maltose. No acid or gas on l-arabinose, rhamnose, dextrose, lactose, sucrose, raffinose, and inulin. Plain gelatine liquefies slowly at the surface after 12 days, and beef extract gelatine after 14 days.

Geotrichum versiforme Moore, spec. nov.

Cellulae plures figuras in mediis diversis habent. Coloniae inter se a panno-villosis holosericisque vel humidis, planis, stellatis vel vermiculatis diversae sunt. Superficies impolita, color albidus vel subalutaceus. Cellulae forma et magnitudine variantes. Hyphae diametro 3–8 μ; cellulae iuniores 6–40 μ longae; arthrosporae 4–9 x 6–18 μ; chlamydosporae sphaericae,

diametro 4–18 μ, chlamydosporae elongatae 6–8 x 20–30 μ; cellulae parvae sphericae 4–6 μ diametro quae blastosporae fieri possunt; cellulae conidio similes, globosae, diametro 4–6 μ, piriformes 3–4 x 4–6 μ. Fermentatio nulla. Acidus per biduum in "l-xylose, galactose, d-mannose, levulose, et maltose." Acidus nullus in "l-arabinose, rhamnose, dextrose, lactose, sucrose, raffinose, et inulin." Gelatina communis per duodecim diebus in summa cuto fluidificans, gelatina decocta bubula per quattordecim diebus fluidificans.

SUMMARY AND CONCLUSIONS

1. A case of bronchiectasis and pulmonary infiltration is reported, from which was isolated an organism identified as a new *Geotrichum*.

2. The fungus, grown in hanging-drops, may develop from an arthrospore to form hyphae, either single or branched, which at maturity form cross-walls and thick walls, breaking up into arthrospores by disarticulation.

3. When grown on a variety of standard media, differing in pH, protein and carbohydrate content, the organism showed different forms on different substrates, developing the largest cells on malt extract agar. The colonies varied from a furry or plush-like growth to a "duvet," flat, moist or vermiculate growth. The color varied from a grayish-white to a creamy-buff.

4. There is no fermentation of any sugar. Acidity is produced with l-xylose, galactose, d-mannose, levulose, and maltose, while an alkaline reaction takes place with l-arabinose, rhamnose, dextrose, lactose, sucrose, raffinose, and inulin. This latter observation may be explained by the breakdown of the amino acids of the medium to alkaline bases, as arginine, histidine and lysine, and also ammonia. Plain gelatine is liquefied after 12 days and beef extract gelatine after 14 days.

5. Because of the several forms on the different media, color production, carbohydrate reactions, and gelatine liquefaction, the organism is described as a new species, *Geotrichum versiforme* Moore.

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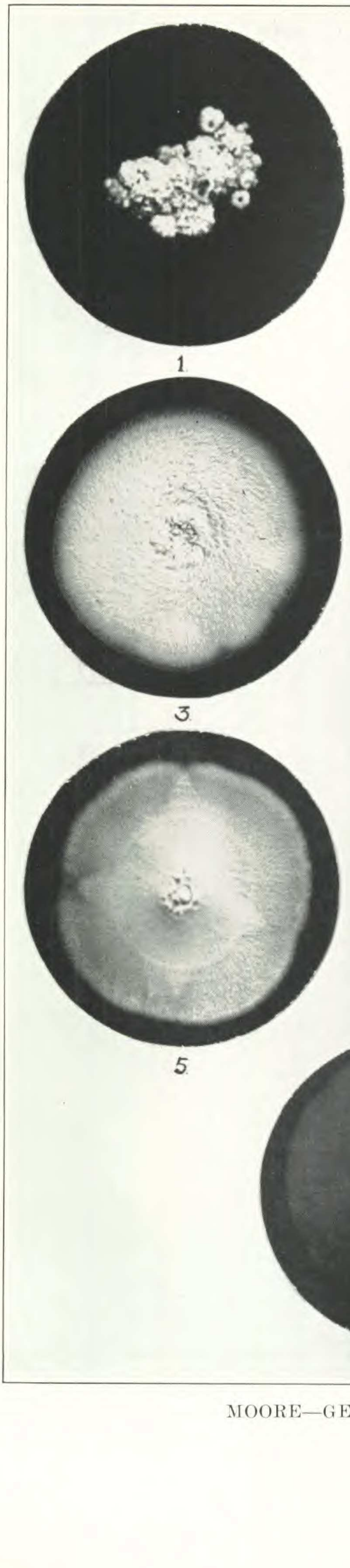
EXPLANATION OF PLATE

PLATE 15

Geotrichum versiforme

Photographs of colonies, 8 days old, on various media.
Fig. 1. Malt extract agar, pH 5.2. × 1.
Fig. 2. Sabouraud's agar, pH 5.6. × 5/8.
Fig. 3. Potato-dextrose agar, pH 5.9. × 5/8.
Fig. 4. Lactose agar, pH 6.8. × 1.
Fig. 5. Glycerine agar, pH 7.0. × 7/8.
Fig. 6. Nutrient agar, pH 7.2. × 7/8.
Fig. 7. Endo's agar, pH 7.5. × 5/8.



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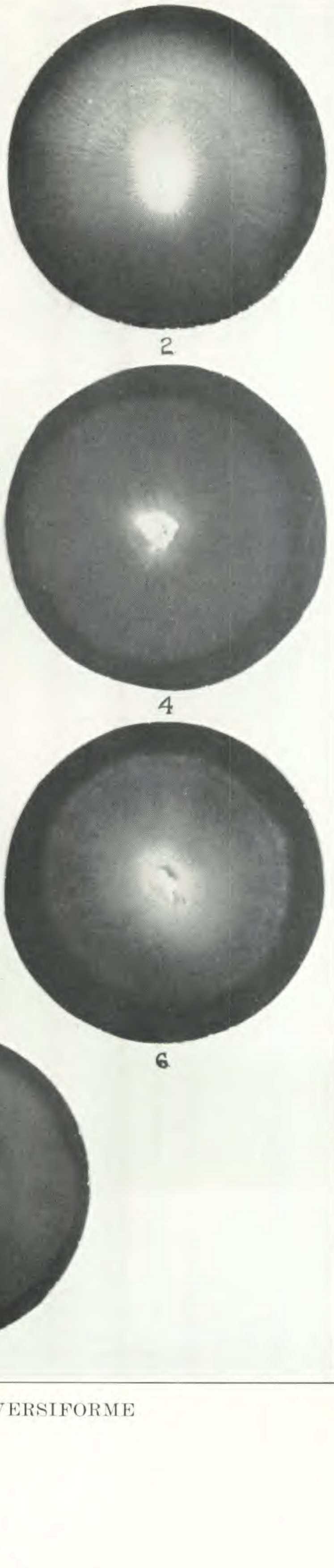

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MOORE—GEOTRICHUM VERSIFORME

EXPLANATION OF PLATE

PLATE 16

Geotrichum versiforme

All figures drawn as correctly as possible at a magnification of × 960 and reduced to × 500, with the aid of a camera lucida.

Fig. 1. Simple arthrospore before germination, on Raulin's agar.

Fig. 2. Germinating arthrospore on Richards' agar.

Figs. 3–5, 7. Germinating arthrospores on Sabouraud's glucose agar.

Fig. 6. Germinating arthrospore on nutrient agar.

Fig. 8. Young filament on glycerine agar.

Fig. 9. Hypnospore-like cell on Sabouraud's glucose agar.

Fig. 10. Young filament showing vacuoles of future arthrospores, on Czapek's agar.

Fig. 11. Mycelium with terminal arthrospores and chlamydospores on malt extract agar.

Fig. 12. Mycelium on potato-dextrose agar.

Fig. 13. Large round chlamydospores on malt extract agar.

Fig. 14. Mycelium showing formation of arthrospores and a conidium-like cell on Czapek's agar.

Fig. 15. Type of cross-wall present on mycelium grown in Sabouraud's broth.

Fig. 16. Mycelium showing pyriform, conidium-like cell on Sabouraud's glucose agar.

Fig. 17. Young mycelium showing vacuoles and arthrospore formation in lactose broth.

Fig. 18. Chains of arthrospores on Raulin's agar.

Fig. 19. Mycelium showing large round chlamydospores, arthrospores, and sclerotic cells on malt extract agar.

Fig. 20. Mycelium showing septal formation and sclerotic cells on malt extract agar.

Fig. 21. Group of rectangular arthrospores on corn-meal agar.

Fig. 22. Mycelium showing arthrospores, rounded and rectangular, on Richards' agar.

Fig. 23. Barrel-shaped arthrospores and an intercalary chlamydospore on malt extract agar.

Fig. 24. Chain of ovoid to round arthrospores on Richards' agar.

Fig. 25. Arthrospore formation on nutrient agar.

Fig. 26. Cell showing cylindrical appearance, on Raulin's agar.

Fig. 27. Arthrospores formed terminally on a filament, on Sabouraud's maltose agar.

Fig. 28. Chain of round cells on Richards' agar.

Fig. 29. Pyriform terminal cell on Raulin's agar.

Fig. 30. Branching filament with arthrospores on Sabouraud's maltose agar.

Fig. 31. Pyriform chlamydospore on Czapek's agar.

Fig. 32. Arthrospores formed within a filament on corn-meal agar.

Fig. 33. Chlamydospore comparable to an akinete as found in algae, on corn-meal agar.

Fig. 34. Terminal chlamydospore on nutrient agar.

Fig. 35. Terminal arthrospores on malt extract agar.